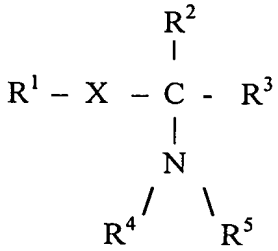
Claims

1. A compound corresponding to formula (I)



in which

- R^1 is a functional group capable of reacting with the functions present on proteins, antibodies or on mineral or organic materials;
- X represents a single bond or a hydrocarbon-based chain consisting of at least one group chosen from alkylene groups and alkenylene groups optionally comprising at least one hetero atom, and from arylene groups;
- R^2 is a group A^2 that is anionic at neutral pH or an alkylene or alkenylene group containing from 1 to 4 carbon atoms and bearing at least one such group A^2, said alkylene or alkenylene group optionally comprising at least one hetero atom in the chain;
- R^3 represents H or an alkylene or alkenylene group containing from 1 to 5 carbon atoms and optionally containing at least one hetero atom in the chain, said group optionally bearing at least one group A^3 that is anionic at neutral pH;
- R^4 is chosen from the groups corresponding to the formula $-(C)_n-C-Z^1-C-C-Z^2-C-A^4$ in which n is equal to 1 or 2, Z^1 and Z^2 represent, independently of each other, a hetero atom chosen from O and N, at least one being a nitrogen atom forming part of an aromatic heterocycle with the two carbon atoms surrounding it, and A^4 is a group that is anionic at neutral pH, in which the atom bearing the anionic charge is in the γ position relative to Z^2;
- R^5 is chosen from the groups defined for R^4 or from groups corresponding to the formula $-C-C-E^1-C-C-E^2-C-A^5$ in which E^1 and E^2 represent, independently of each other, a

hetero atom chosen from O and N, and A^5 is a group that is anionic at neutral pH, in which the atom bearing the anionic charge is in the γ position relative to E^2.

2. The compound as claimed in claim 1, characterized in that the substituent R^1 is chosen from amino, thio, cyano, isocyano, acridinyl, hydrazino, haloacetate, anhydride, triazo, carbonyl, nitrobenzoyl, sulfonyl, thionyl, halide, epoxide, aldehyde, imidazole, hydroxyphenyl, mercapto, N-succinimidyl ester, N-sulfo-succinimidyl ester, maleimido, hydroxyl, carboxyl, thiocyano, and isothiocyano groups.

3. The compound as claimed in claim 1, characterized in that the substituent R^2 is a group A^2 that is anionic at neutral pH.

4. The compound as claimed in claim 1, characterized in that the substituent R^3 is H or a C_1 to C_3 alkyl.

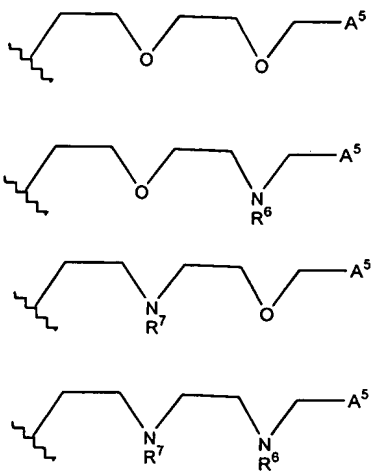
5. The compound as claimed in claim 1, characterized in that the groups Z^1 and Z^2 of R^4 form part of an aromatic heterocyclic group.

6. The compound as claimed in claim 1, characterized in that n is equal to 1.

7. The compound as claimed in claim 1, characterized in that one of the segments -C-Z^1-C- or -C-Z^2-C- forms part of a heterocyclic group chosen from pyridyl, pyrimidinyl, quinolyl and isoquinolyl groups.

8. The compound as claimed in claim 1, characterized in that the segment -C-Z^1-C-C-Z^2-C- is chosen from 2,2′-bipyridinyl, 1,10-phenanthrolinyl, 2,2′-bisquinolyl, 2,2′-bisisoquinolyl and 2,2′-bipyrimidinyl groups, said groups possibly bearing alkyl or alkoxy substituents on at least one carbon atom of a heterocycle.

9. The compound as claimed in claim 1, characterized in that R^5 is chosen from the following groups:



in which R^6 and R^7 represent alkyl chains containing from 1 to 5 carbon atoms and optionally containing one or more hetero atoms.

10. The compound as claimed in claim 1, characterized in that R^4 and R^5 are identical.

11. The compound as claimed in claim 1, characterized in that the groups A^2, A^3, A^4 or A^5 that are anionic at neutral pH are chosen, independently of each other, from $-CO_2H$, $-SO_3H$, $-P(O)(OR)OH$, $-P(O)R(OH)$ and $-P(O)(OH)_2$ groups in which R is an alkyl group or an aryl group.

12. The compound as claimed in claim 1, characterized in that it is in cationic form, the nitrogen bearing the substituents R^4 and R^5, and also possibly the hetero atoms Z^1, Z^2, E^1 and E^2, being in protonated form.

13. The compound as claimed in claim 1, characterized in that it is in anionic form, the various groups A^i being in the form of salts.

14. The compound as claimed in claim 1, characterized in that it is in zwitterionic form, the nitrogen bearing the substituents R^4 and R^5, and also possibly the hetero atoms Z^1, Z^2, E^1 and E^2, being in protonated form, and the various groups A^i being in the form of salts.

15. The compound as claimed in claim 1, characterized in that X is an arylene group comprising one or more fused or unfused aromatic nuclei, said nucleus (nuclei) optionally bearing one or more aliphatic hydrocarbon-based groups.

16. The compound as claimed in claim 1, characterized in that the group X is an alkylene or alkenylene group containing from 1 to 10 carbon atoms.

17. The compound as claimed in claim 1, characterized in that the group X is an arylene group containing from 5 to 10 carbon atoms.

18. A process for preparing a lanthanide complex, characterized in that it consists in reacting a compound (I) as claimed in any one of claims 1 to 17 with a compound giving a lanthanide cation.

19. The process as claimed in claim 18, characterized in that the compound giving a lanthanide cation is chosen from lanthanide halide hydrates, lanthanide nitrate hydrates, lanthanide carbonates and lanthanide triflates.

20. The process as claimed in claim 18, characterized in that the reaction is performed in solution in a solvent chosen from water, methanol, ethanol and acetonitrile.

21. The process as claimed in claim 18, characterized in that compound (I) is reacted with the lanthanide ion precursor in a mixture of methanol and water at a pH ranging from 3 to 5, for a time of between 10 minutes and 24 hours, at a temperature of between 25°C and 80°C, and the pH of the solution is then adjusted to 7.0 and the methanol is evaporated off.

22. A complex obtained via a process as claimed in claim 18, consisting of a lanthanide ion Ln complexed with a ligand corresponding to formula (I).

23. The complex as claimed in claim 22, characterized in that the lanthanide ion is chosen from europium, terbium, samarium, dysprosium, erbium, ytterbium, neodymium and gadolinium ions.

24. The complex as claimed in claim 22, characterized in that the substituent R^4 of the compound (I) is $-C-C-Z^1-C-C-Z^2-C-A^4$, the 3 chelate rings being formed between the lanthanide cation and, respectively:

- the N atom bearing R^4 and R^5, Z^1 and the carbon atoms that separate them;

- Z^1, Z^2 and the two carbon atoms that separate them;
- the end segment Z^2-C-A^4.

25. The complex as claimed in claim 24, characterized in that the substituent R^5 is of the same type as the substituent R^4.

26. The complex as claimed in claim 24, characterized in that the substituent R^5 is of the type -C-C-E^1-C-C-E^2-C-A^5, three 5-membered chelate rings being formed between the lanthanide cation and, respectively:

- the N atom bearing R^4 and R^5, E^1 and the two carbon atoms that separate them;
- E^1, E^2 and the two carbon atoms that separate them;
- the end segment E^2-C-A^5.

27. A process for the quantitative or qualitative analysis of a compound, characterized in that it consists in covalently bonding to said compound a marker consisting of a complex as claimed in one of claims 25 to 29, and in detecting or quantifying the presence of the marked compound by means of the luminescence properties of the marker.

28. The process as claimed in claim 27, characterized in that the complex is a europium, terbium, samarium or dysprosium complex.

29. The process as claimed in claim 27, characterized in that the substituent R^1 of the complex is chosen from amino, thio and carboxyl groups or from maleimido, N-succinimidyl ester and isothiocyano groups.

30. A relaxation agent for nuclear magnetic resonance, consisting of a complex as claimed in one of claims 22 to 26.

31. The relaxation agent as claimed in claim 30, characterized in that it consists of a gadolinium, europium or dysprosium complex.

32. The relaxation agent as claimed in claim 30, characterized in that it consists of a complex in which the substituent R^1 is chosen from amino, thio and carboxyl groups or from maleimido, N-succinimidyl ester and isothiocyano groups.